THE RADIO SPECTRUM POLICY GROUP's (RSPG) CONSULTATION ON STRATEGIC SPECTRUM ROADMAP TOWARDS 5G FOR EUROPE
2nd Draft RSPG Opinion on 5G networks

Background

ESOA welcomes the opportunity to respond to the draft RSPG Second Opinion on 5G networks. ESOA notes this is a further development of the roadmap to facilitate the launch of 5G on a large scale in Europe starting in 2020 and that the goal of the RSPG is that the benefits of 5G-based services are made available to all European citizens in a timely manner, driving industrial and societal transformation and economic growth in Europe from 2020 and beyond.

In November 2016 a strategic roadmap for 5G was first established when the RSPG adopted and published its first "Opinion on spectrum related aspects for next generation wireless systems (5G) " where it was outlined what spectrum will be needed for next-generation wireless systems.

An opinion was sought in order to build on RSPG's efforts and contribute actively to the development of Europe's spectrum policy strategy regarding 5G.

The work in 2016 focused on identifying the pioneer frequency blocks needed for a rapid launch of new wireless services in the next generation wireless systems:

- 3.6 GHz (3400-3800 MHz) will be the first primary band for 5G and bring the necessary capacity for new 5G services
- 26 GHz (24.25-27.5 GHz) will be the pioneer band in Europe above 24 GHz to give ultra-high capacity for innovative new services, enabling new business models and sectors of the economy to benefit from 5G
- 5G can be launched over the existing EU harmonised mobile bands, including in particular bands below 1 GHz which can enable 5G coverage to all areas (e.g. 700 MHz) ensuring that everyone benefits, while enabling the transition from the current to the next generation of networks

ESOA's comments hereby are issued in response to the RSPG call of 23 November 2017[1] on the RSPG's second Opinion on 5G networks which exposes some of the conditions under which these pioneer frequency bands are to be made available within the EU.

ESOA Response Contents:

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[1] as published on http://rspg-spectrum.eu/public-consultations/

1. About ESOA

ESOA is a non-profit organisation established with the objective of serving and promoting the common interests of EMEA satellite operators. The Association is the reference point for the European, Middle Eastern, and African satellite industry and today represents the interests of 34 members, including satellite operators who deliver information communication services across the globe as well as EMEA space industry stakeholders and insurance brokers.

2. Executive Summary

ESOA believes that it will not be possible to realise a viable 5G ecosystem and ubiquitous coverage without the integration of satellites into 5G networks. As well as extending the reach of 5G terrestrial systems, satellite communications will be essential to an invisible and resilient overlay for terrestrial networks to realise the EU vision for the 'Gigabit Society'; a society in which millions of connections between people, devices, and things will require inter-connectivity and stability at unprecedented levels that terrestrial networks alone cannot deliver for Europe's citizens.

ESOA is supportive of the leadership from EU policy makers on 5G policy, and our primary concern is to ensure measures taken to release spectrum for 5G in Europe do not in any way prejudice existing frequency users or impact current and future service offerings in the whole 3.4-4.2 GHz band. In particular, ESOA wishes to underline the fact that European satellite operators have invested large sums of money in developing Fixed-Satellite Service (FSS) communications platforms and networks in the conventional C-band (above 3800 MHz). Therefore, we are concerned that any hasty decisions to clear some parts of the C-band band in order to "free up" spectrum for terrestrial 5G applications would undermine the investments made by satellite operators and service providers in this band and have a negative impact on European industry and consumers relying on C-band FSS services.

ESOA acknowledges that the band 24.25 -27.5 GHz ("26 GHz band") is the focus of 5G spectrum identifications and future authorisations. The authorisation regime for 5G should include explicit terms and conditions that enable the future viable and sustainable use of this band by FSS/EESS/SRS services and to protect EESS/SRS earth stations and FSS space stations from unacceptable emissions.

ESOA strongly supports the RSPG's view that the 66 - 71 GHz band should be prioritised for 5G/IMT-2020, but believes that the RSPG should go further than prioritising this band for technical studies. ESOA believes that there are compelling arguments why the 66 - 71 GHz should become the primary European band for 5G services and notes that this band could provide five network operators with up to 1 GHz of exclusive spectrum to deliver 5G services each.

ESOA also recommends that the RSPG is extending the 66 – 71 GHz band to 71 - 76 GHz by using the existing co-primary mobile allocations. Not only could this doubling make it possible to achieve the EC Digital Agenda goal of 100 Mbit/s connectivity, but opening 10 GHz of spectrum from 66 - 76 GHz could afford significant future-proofing for that goal.

ESOA could further support the inclusion of the 40.5 – 43.5 GHz band for 5G / IMT-2020 use in Europe provided an appropriate shared basis with space / satellite services is developed in that band which enables the long term sustainable and viable use by the space services. This band will remain necessary for FSS applications, in particular for coordinated earth stations.

3. ESOA's Response

Role of Satellite in an integrated 5G ecosystem

3.1. The European Commission set a goal of having access to a 100 Mbit/s broadband service in 100% of the EU by 2025. In addition, numerous EU member states have adopted the EC Broadband 2020 goals of 100 Mbit/s connectivity to 50% of EU citizens by the year 2020 and 30 Mbit/s connectivity to 100% of EU citizens. ESOA believes that these goals cannot be realised without the use of satellites, as a component of the 5G ecosystem.

3.2. Satellite communications already delivers mobile backhaul, push data services, linear and non-linear TV, converged media, broadband services and many M2M services that will be part of the 5G ecosystem in Europe and world-wide. In the future, consumers of 5G services will also expect to be able to use their devices in aircraft, ships and vehicles and in remote areas; and the continuity of 5G networks will be critical in times of natural disasters or terrestrial network outages. Satellite communications is a means to support these important aspects of 5G deployment scenarios.

3.3. The 5G ecosystem is envisioned as a highly-advanced, ubiquitous eco-system of integrated networks providing a wide range of services to consumers globally. The geographic coverage, network resilience, flexibility and efficiency of 5G networks will require a wide range of networking technologies, particularly for backhaul of the large volume of traffic that they are expected to carry. The integration of satellites into 5G is, therefore, essential.

3.4. There are several characteristics of satellite technology that make it well suited to supporting 5G networks:

- **Reach** – With a single geostationary orbit satellite it is possible to provide communications over the entire European region. This capability allows satellite to act as a back-up for terrestrial communications, and deliver services solely by satellite

- **Scalability** – Using broadcast technology, a single geostationary orbit satellite can simultaneously deliver a range of services, from software updates to video content, directly to end users. This significantly reduces costs for manufacturers and content providers

- **Ready for Launch** – Only a fraction of major transport corridors in the EU have complete 4G coverage at present.[2] By comparison, satellite communications companies already have satellites ready to deliver service, once vehicles are fitted with new antennas and related communications equipment

[2] *See* National Infrastructure Commission, *Connected Future* (London, 2016), available at https://www.nic.org.uk/wp-content/uploads/Connected-Future-Report.pdf

3.5. As well as extending the reach of 5G terrestrial systems, satellite communications will provide an invisible and resilient overlay for terrestrial networks to realise the vision for the 'Gigabit Society'. This is a society in which millions of connections between people, devices, and things will require inter-connectivity and stability at unprecedented levels that terrestrial networks alone cannot deliver.

ESOA Views on the draft 2nd Opinion

ESOA herebelow comments on the ten (10) paragraphs ("Paras") of the text of the draft Opinion (pages 4-5).

ESOA supports the RSPG's Para 1 - that Member States will in general need flexibility in the way they authorise access to spectrum using both individual licencing or a general authorisation framework. Both types of regime are used by Member States to authorise satellite services.

3.6. By 2020-2025 there will be over 100 High Throughput Satellite (HTS) and Very High Throughput Satellite (VHTS) systems in orbit delivering Gigabits of connectivity across the world using Ku and Ka bands and in the future in Q/V band. These satellites will also provide cyber-resilience and data connectivity backup, especially for M2M networks.

ESOA supports the RSPG's Para 2 - even considering that the 5G ecosystem and ubiquitous coverage cannot be realised without satellites.

3.7. Only a complementary operation of satellite and terrestrial technologies will enable a high-speed, robust, inclusive 5G ecosystem. On that regard, the ongoing Satellite and Terrestrial Network for 5G (SaT5G) project financed by the H2020 program of the EU will research, develop and validate key technologies required to enable the plug-and-play integration of satellites into 5G networks.

ESOA supports the RSPG's Para 3 - and is of the view that this precisely recognises the value of integrating satellites into 5G networks, as exemplified by the SaT5G research project mentioned above.

ESOA supports the RSPG's Paras 4 and 5 - on 5G performance requirements and coverage obligations.

ESOA supports the RSPG's Para 6 - but would like the RSPG to note that solving issues relating to facilitating the efficient deployment of ultra-dense 5G networks in dense urban areas will require inter-connectivity and stability at unprecedented levels that terrestrial networks alone cannot deliver.

ESOA objects to RSPG's Para 7 – as we believe that forcing that all 5G commercial licenses are subject to trading or leasing is not only unnecessary, but could encourage Member States to exclude viable business models and reduce competition.

3.8. The trading or leasing of spectrum licences has only been successfully in the context of commercial terrestrial networks and stations - and trading and leasing of spectrum licences is not sufficient to enable a secondary market to operate efficiently in all cases. Furthermore, European legislation already allows Member States the flexibility to implement trading or leasing should they wish to. Therefore, ESOA urges the RSPG to further study whether the trading and leasing of spectrum licences has been proven to enable new market opportunities to be delivered by terrestrial and satellite networks in all circumstances.

ESOA acknowledges that the 24.25 -27.5 GHz band (the "26 GHz band") is the focus of 5G spectrum identifications and future authorisations, as noted in the RSPG's Para 9. The authorisation regime for 5G should include explicit terms and conditions that enable the future viable and sustainable use of this band by FSS/EESS/SRS services and to protect from unacceptable EESS/SRS earth stations and FSS space stations.

3.9. ESOA believes that the Commission should include as part of any technical harmonisation for the 26 GHz band the requirement to maintain the viable scope for continued development of incumbent satellite services (FSS and EESS/SRS). Future satellite earth stations should be authorised based on transparent, objective and proportionate criteria to safeguard their future operations and service capabilities. However, ensuring that they are unlikely to have a significant impact on 5G deployment and coverage will require the development and implementation of sharing criteria and mitigation methods acceptable to all users and Member States.

3.10. ESOA understands that Member States should remain fully responsible for granting or rejecting authorisation to new satellite earth station applications in the 26 GHz band, expecting that EU national administrations will duly ensure continued and future coexistence with 5G terrestrial systems whenever and wherever possible.

3.11 ESOA considers that 5G deployment in the 26 GHz frequency range is expected to be used for local coverage.

3.12 ESOA does not agree that regulatory flexibility for the progressive release of the 26 GHz band will facilitate an efficient introduction of 5G without having an unnecessary negative impact on the current users of the band. ESOA would want to see the details of the release plans in full before it concludes on its view.

3.13 ESOA has no view on whether Member States should plan any migration of Fixed Services links necessary for ensuring the availability of the band for 5G, taking into account the geographical dimension / extent of the market demand for 5G.

3.14 Given the various sharing constraints with other in-band co-primary terrestrial services and co-primary satellite services in the 24.25 – 27.5 GHz band and given the emerging challenges of sharing high 5G/IMT stations with poor unwanted emissions characteristics with sensitive passive services below 24.25 GHz, ESOA believes it makes sense to take action *now* to also prioritise the 66 – 71 GHz, 71 – 76 GHz and '42 GHz' bands for 5G / IMT-2020 use in Europe.

3.15 ESOA strongly supports the RSPG's Opinion that the 66 - 71 GHz band should also be prioritised for 5G/IMT-2020. ESOA even believes that more emphasis should be placed on using 66 - 71 GHz in an early timeframe (i.e. as from 2019 or even 2018) for 5G / IMT-2020 in Europe. ESOA recommends that spectrum in the 66 - 71 GHz range should be identified in 2018 by the RSPG to become a primary European band for available use by 5G / IMT services as from 2019 (or earlier).

3.16 ESOA fully supports 66 – 71 GHz being prioritised for 5G in Europe for the following reasons:

- A recent CEPT questionnaire[3] found there was no reported use of 66 - 71 GHz in most CEPT countries
- Its proximity to the 57 - 66 GHz band, already designated and used for WiGig, indicates that 5G equipment could potentially be available in this band relatively early by benefiting from the ecosystem being developed in the adjacent band
- It has already a primary ITU allocation to the terrestrial mobile service
- It can support very high data rate 5G service including in high density urban and sub-urban indoor environments and outdoor environments
- It can support up to say 1 GHz per mobile operator planning to deliver 5 GHz / IMT-2020 service
- It has better propagation characteristics than the adjacent 57 - 66 GHz band (as it's outside the O2 absorption peak) and therefore can be a viable alternative to lower mm-wave bands for cell radiuses ranging from 50 to 200m or higher

3.17 ESOA also recommends that RSPG take action to prioritise studies for the future use of the 71 – 76 GHz and 81 – 86 GHz bands for 5G/IMT-2020, including scope for sharing with existing space and terrestrial services in these bands. The near term identification of 71 – 76 GHz for 5G/IMT-2020 in Europe should be beneficial as it would allow for up to 10 GHz of contiguous spectrum between 66 – 76 GHz for future 5G/IMT-2020 services.

3.18 ESOA could support the inclusion of the 40.5 – 43.5 GHz band for 5G / IMT-2020 use in Europe provided an appropriate shared basis with space / satellite services is developed in that band which enables the long term sustainable and viable use by the space services. The mobile industry has indicated that the 40.5 - 43.5 GHz band is expected to be part of a tuning range for 5G / IMT-2020 equipment from 37.0 - 43.5 GHz. ESOA considers that the potential for 5G to develop in this tuning range of 37.0 – 43.5 GHz will vary in different regions of the world and an identification for 5G/IMT-2020 services in Europe via relevant EU / CEPT actions within the 40.5 – 43.5 GHz band on a shared basis with space and terrestrial services should be progressed. It should be noted that other bands in the vicinity of 40.5-43.5 GHz will be needed for FSS applications which use uncoordinated, ubiquitous terminals. The 39.5-40.5 GHz band in particular is identified by CEPT for uncoordinated FSS applications and therefore could not be available for terrestrial 5G in Europe.

ESOA acknowledges that Member States are considering appropriate measures to defragment the 3400-3800 MHz band, the primary 5G band in the EC, as per the RSPG's Para 8 - in time for authorising sufficiently large blocks of spectrum by 2020.

3.19 ESOA recognises the interest in this band for 5G in Europe and the need to resolve the mixed frequency assignments that have been made to terrestrial broadband systems in the past. ESOA wishes to emphasise that this band will continue to be required for FSS earth stations in Europe and hence 5G deployments in this band will need be on a shared basis with currently operating earth stations. It is also important to note that this band is very heavily used for FSS earth stations in other

[3] See Summary of responses to questionnaire on bands for AI1.13, September 2016 – available from: https://cept.org/ecc/groups/ecc/ecc-pt1/client/meeting-documents/file-history/?fid=32182

parts of the world and that will effectively prevent internationally harmonised use of this band for 5G.

ESOA fully agrees with the RSPG's Para 10 that the application of a general authorisation regime to the 66-71 GHz band is appropriate - in the context of the physical characteristics of this band and its use for very short range, very high bandwidth communications. However, ESOA believes the use of individual authorisations in this band or in the 71 – 76 GHz band should not be precluded.

Further Spectrum Considerations

3.20 Long term viable and sustainable spectrum access for GEO and Non-GEO HTS / VHTS satellite systems / services is central to the successful contribution of satellite to the 5G ecosystem. The European Commission has already placed the spectrum discussion centre-table and has published a strategic roadmap for 5G spectrum[4] which the CEPT has mirrored with its own 5G roadmap.

3.21 ESOA agrees that a range of spectrum resources will be required to satisfy the diverse requirements anticipated for 5G / IMT-2020 networks. Of the bands identified in ITU Resolution 238 (WRC-2015) for study for potential 5G/IMT-2020 use, satellite systems will need to continue to access and use on a long term sustainable and viable basis the various existing ITU allocated satellite / space service services allocations, including within 24.25 – 27.5 GHz and in relevant segments of the "40 GHz" bands.

3.22 ESOA considers that the band 27.5 – 30 GHz should not be considered for 5G/IMT-2020 in Europe consistent with ITU Resolution 238 and CEPT's position on WRC-2019 agenda item 1.13, taking also into the huge investments already made into Ka-band GEO and Non-GEO satellite systems and associated services being delivered and planned to be delivered. ESOA strongly urges the RSPG to ensure that the 27.5 – 30 GHz frequency range remains out of scope for terrestrial mobile services, including 5G, to ensure that 5G satellite communications can provide an invisible and resilient overlay for terrestrial networks to realise the EC's vision for the 'Gigabit Society'.

[4] RADIO SPECTRUM POLICY GROUP: STRATEGIC ROADMAP TOWARDS 5G FOR EUROPE: Opinion on spectrum related aspects for next-generation wireless systems (5G) - RSPG16-032 FINAL

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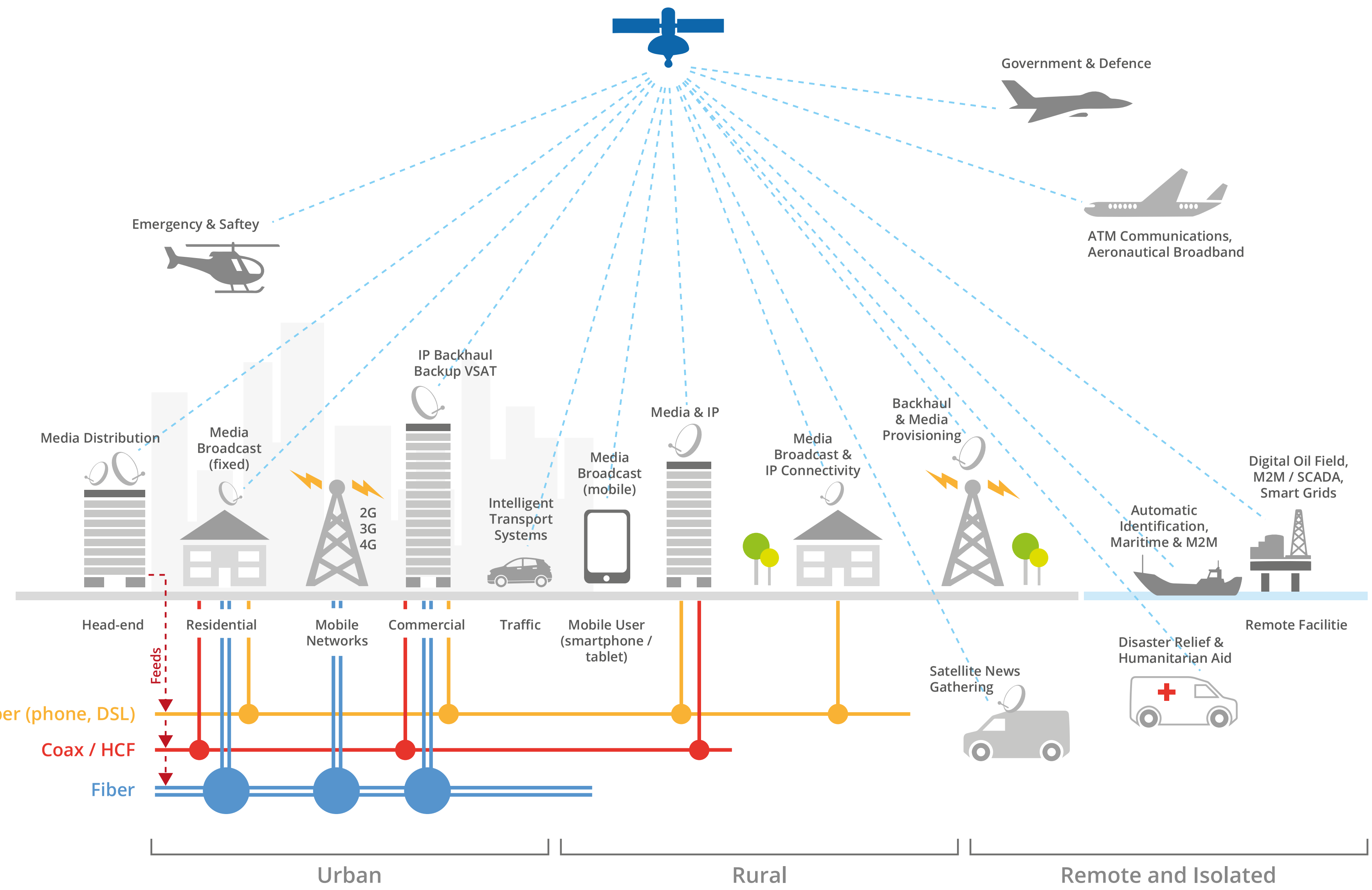
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Rural
Remote and Isolated

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Executive summary

Satellites will play a vital role in future 5G networks, and the benefits to users, including consumers, governments and industry, will come not from individual technologies, but from the quantum difference these services will make to mankind. ESOA's[1] members will make a valuable contribution to these cutting edge developments.

5G will be a network of networks - an ecosystem - with multiple technologies supporting a global infrastructure: satellite, Wi-Fi, small cells, and traditional mobile wireless networks, among others. Satellites have a particularly important role to play bringing services to users quickly, no matter where they are located and no matter the availability of terrestrial infrastructure. Satellites have three key characteristics that are critical for the success of 5G: wide area coverage, cost-effectiveness, and reliability (resilience).

Wide area coverage and reduced vulnerability of physical attacks and natural disasters allow space-based satellite networks to:

- Foster the roll out of 5G service in areas that cannot be covered by terrestrial networks (e.g. isolated/remote areas, on board aircrafts or vessels);
- Upgrade the performance of limited terrestrial networks in a cost effective manner in underserved areas (e.g. sub-urban/rural areas);
- Reinforce 5G service availability by providing service continuity for M2M/IoT devices or connectivity and autonomy of intelligent cars with software updates on board moving platforms (e.g. passenger vehicles, aircraft, ships, high speed trains, bus, etc.);
- Ensure service anywhere, especially for critical communications, future railway train communications, and maritime communications;
- Enable 5G network scalability by providing efficient global multicast/broadcast coverage resources for data delivery;
- Create a reliable and ubiquitous communication system that is both highly secure and economically viable.

1 ESOA is the "EMEA Satellite Operators Association," a non-profit organisation serving and promoting the common interests of satellite operators from Europe, the Middle East, Africa and the Commonwealth of Independent States (CIS). The Association today represents the interests of 21 satellite operators who deliver information communication services around the globe.

Introduction

5G is the next generation of wireless access technology that much of the world is moving towards. By supporting a world in which "anyone and anything will be connected at anytime and anywhere"[2] , 5G is expected to enable new applications in various domains, including entertainment, health, automotive, transport and industry. The advanced communications of 5G are expected to bring enhanced mobile broadband, ultra-reliable communications, and massive machine-type communications.[3]

This next generation network has been described as having significantly more capacity and higher user data rates than today's capabilities, so as to meet the growing demands of users. In addition, an important goal of 5G is to provide increased resilience, continuity, and much higher resource efficiency including a significant decrease in energy consumption. Finally, security and privacy will need to be ensured to protect users and the important amounts of data that will be carried across the network.

The following requirements are often referenced for 5G:

- 1-10Gbit/s connections to end points in the field (i.e. not a theoretical maximum);
- 1 millisecond end-to-end round trip delay (latency in the access network, implying that content must be located close to the edge);
- 100x bandwidth per unit area;
- 10-100x number of connected devices;
- (perception of) 99.999% availability;
- (perception of) 100% coverage;
- 90% reduction in network energy usage;
- Up to ten-year battery life for low power, machine-type devices.

No single technology will meet all of these needs, and not all of these characteristics will be required for every 5G application. On the contrary, as the European Commission and other governments around the world have correctly recognized, to be successful and meet user demands, the 5G infrastructure will be an ecosystem of networked networks, utilizing multiple different and complementary technologies.

2 See, for example: http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/573892/EPRS_BRI(2016)573892_EN.pdf

3 GSMA, "5G Spectrum: Public Policy Position" (Nov. 2016).

The Technologies of the 5G Ecosystem

▶ A Technology Neutral Ecosystem

5G is intended to significantly improve the lives of citizens who, in a globalized world, are increasingly used to having always-on connectivity on multiple devices for a range of different purposes no matter where they are.

It is well recognised that Internet access, whether fixed or mobile, fosters inclusion and brings social and economic advantages to people no matter where they live. 5G should not be reserved for the urban elite even though the reality of telecoms operators' business models will likely result in the most densely populated areas being served as a priority.

At the same time, many countries still suffer from a Digital Divide. If this DIgital Divide is not to become a Digital Chasm, then policy making, to achieve widespread 5G deployment needs to be ambitious. This ambition must not only ensure that 5G networks are rolled out in urban areas but also help combat poverty and provide opportunities in communities in rural areas in developed as well as emerging economies. In the European Union around 27% of all citizens live in rural areas.[4] Further, in the United States, 39% of rural residents do not have access to terrestrial broadband.[5] 5G policymaking therefore needs to be balanced, holistic and technology neutral, striving to bring the best connectivity to all areas, many of which today have little or no connectivity at all without use of satellite communications.

Accordingly, a technology neutral approach to 5G that enables an entire ecosystem with competition between platforms is critical. Without such an approach, the benefits of 5G will remain untapped for most people, leaving them excluded and left behind in a world that is racing ahead in its technological developments. Only layers of complementary networks that play to the strengths of different technologies will complete the 5G vision that policymakers have for tomorrow's connected communities.

The integration of several (at times currently separated) heterogeneous networks to reach extremely ambitious goals in terms of range of services, performance, availability and programmability will also serve to make the business plans of different vertical industries viable by allowing their services to be provided ubiquitously and with stability in the network.

4 http://ec.europa.eu/eurostat/statistics-explained/index.php/Urban_Europe_%E2%80%94_statistics_on_cities,_towns_and_suburbs_%E2%80%94_patterns_of_urban_and_city_developments (In 2014, 72.5 % of EU-28 inhabitants lived in cities, towns and suburbs)

5 https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2016-broadband-progress-report.

▶ The Role of Satellite in the 5G Ecosystem

Many organizations, including the European Commission,[6] recognize that satellite networks will be a component of 5G infrastructure.

Not only can satellites provide ubiquitous, anytime coverage, but they can provide cost-effective coverage to many areas of the globe, which might otherwise go unserved.

Satellites are the only means to provide truly ubiquitous geographic coverage and mobility.

This feature is critical to the successful deployment and operation of 5G:

- Complementing connectivity for mobile nodes (ships, airplanes, vehicles and trains);
- Offloading a temporarily congested network;
- Providing backhauling services to fixed or moving base stations; and
- Providing emergency response/disaster recovery communications.

Satellites are inherently well suited to broadcast or multicast one-to-many transmission links, usually over long distances and large areas to multiple distribution hubs such as radio access points. Satellites can deliver very high data rate services in broadcast / multicast mode (e.g. data broadband connectivity and IP enabled video distribution via satellite) as well as in unicast mode.

Satellites today can deliver very high data (> 100 Mbps – 1 Gbps) in broadcast mode to outdoor radio access points for:

- High capacity two-way broadband services for complementary coverage to fixed or terrestrial wireless networks outside major urban / suburban areas;
- Direct delivery of linear / non-linear video transmissions TV / IPTV services to in-building fixed customers;
- Interconnection via 3G/ 4G / 4G+ / RLAN wireless access networks (for in-home / in-building distribution) for service delivery to in-building 'mobile' users.

The diversity of designs amongst satellite systems also contributes to their utility in support of the 5G ecosystem. **Increasingly, satellite systems deliver greater capabilities at lower costs by leveraging the particular characteristics of each system's global reach:**

- A single geostationary satellite can provide communications downlinks over wide areas, such as entire countries or continents, including to rural areas with no terrestrial connections. Further, a single satellite in geostationary orbit can deliver high-bandwidth, high-reliability services to a large number of connected devices, whether fixed or in-motion, simultaneously across a wide geographic region.
- Constellations of non-geostationary satellites can deliver high-capacity services to localized areas with the low latency that some applications require. Such satellites are operating already, with more constellations being planned for the 2020 timeframe, in time to participate fully in the 5G ecosystem.

Leveraging these varied strengths expands the range, capacity, and capabilities of 5G systems.

6 http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=17131

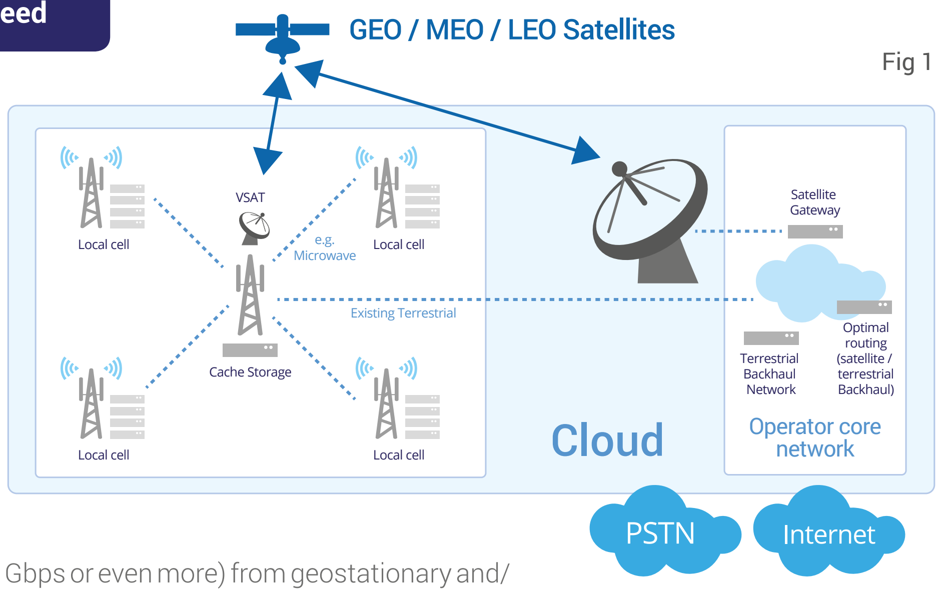
Satellite Use Case

Satellite-based solutions will be fluidly integrated in into Next Generation Access Technologies, enabling a broad range of use cases where the benefits of satellite can be leveraged.

Four broad classes of use cases that are immediately identified are trunking, back-haul, communications on the move and hybrid multiplay, each of which are explored in more detail below.

Trunking and Head-end Feed

This use case addresses high speed trunking of video, IoT and other data to a central site, with further terrestrial distribution to local cell sites, for instance neighbouring villages, as shown in figure 1.



A very high speed satellite link (up to 1 Gbps or even more) from geostationary and/ or non-geostationary satellites will complement existing terrestrial connectivity.

Examples of this Use Case include:

- Broadband connectivity to areas where it is difficult or not possible to deploy terrestrial towers, for example, maritime services, coverage on lakes, islands, mountains or other areas that are best or only covered by the satellites; across a wide geographic region.
- Disaster relief: During natural disasters or other unforeseen events that entirely disable the terrestrial network, satellites are often the only option;
- Emergency response: besides wide-scale natural disasters, there are specific emergency situations in areas where there is no terrestrial coverage. An example of this situation is public safety response following an accident in a power plant
- Broadband connectivity to tactical cells for mission critical communications;
- Broadband connectivity for network head-end;
- Secondary/backup connection (limited in capability) in the event of the primary connection failure or for connected cars. Enabling Over-the-Air Firmware and Software (FOTA/SOTA) services to get information updates, such as information regarding Points of Interest (POIs), real-time traffic, and parking availability (“infotainment”).

Backhauling and Tower Feed

This use case is about high speed backhaul connectivity to individual cells, with the ability to multicast the same content (e.g. video, HD / UHD TV, as well as other non-video data) across a large coverage (e.g. for local storage and consumption), as shown in the graph below. The same capability also allows for the efficient backhauling of aggregated IoT traffic from multiple sites.

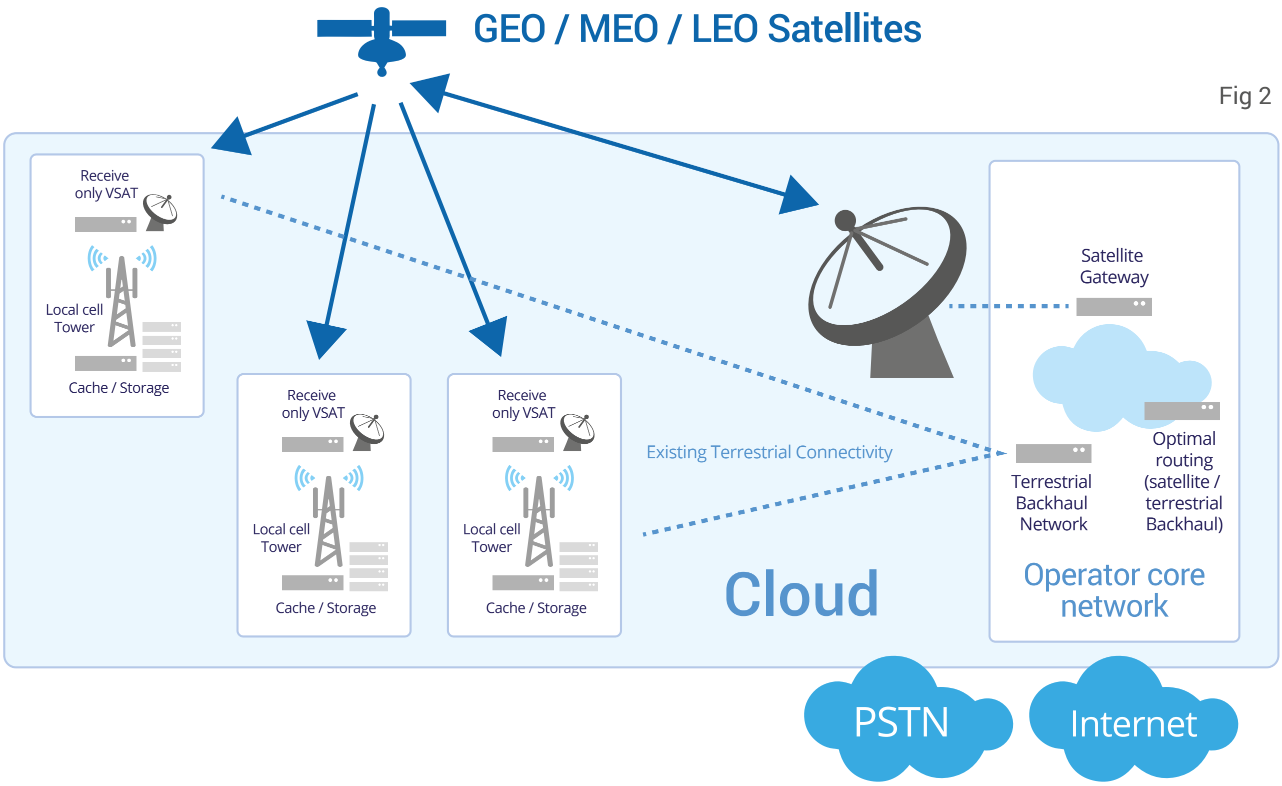


Fig 2

A very high speed, multicast-enabled, satellite link (up to 1 Gbps or even more), direct to the cell towers, from geostationary and/or non-geostationary satellites will complement existing terrestrial connectivity.

Examples of such Use Case include:

- **Broadcast service to end users, vehicles, etc. (e.g. video, software download), support of low bit-rate broadcast service e.g. for emergency messages and synchronisation of remote sensors and actuators;**
- **Providing efficient multicast/broadcast delivery to network edges for content such as live broadcasts, ad-hoc broadcast/multicast streams, group communications, MEC VNF update distribution.**

Communications on the Move

This use case is about high speed backhaul connectivity to individual in-motion terminals on planes, vehicles, trains and vessels (including cruise ships and other passenger vessels), with the ability to multicast the same content (e.g. video, HD / UHD TV, FOTA, as well as other non-video data) across a large coverage area (e.g. for local storage and consumption), as shown in the graph below. The same capability also allows for the efficient backhauling of aggregated IoT traffic from these moving platforms.

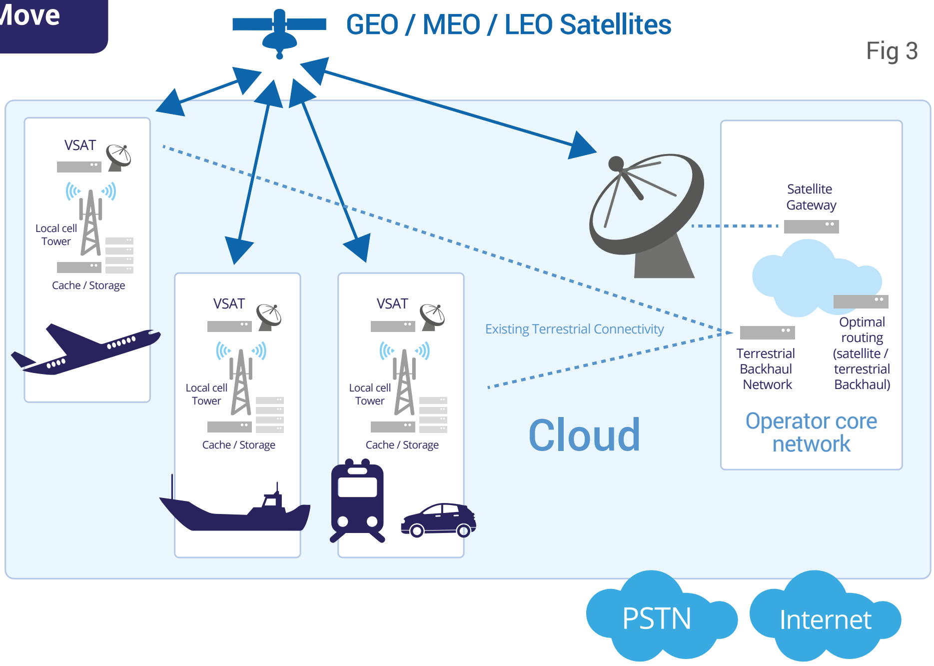


Fig 3

A very high speed, multicast-enabled, satellite link (up to 1 Gbps or even more), direct to the plane, vehicles, train or vessel, from geostationary and/or non-geostationary satellites will complement existing terrestrial connectivity where available.

Examples of this Use Case include:

- Connectivity complementing terrestrial networks, such as broadband and content multicast connectivity to phased-array platforms on the move, in conjunction with a terrestrial-based connectivity link to base stations or relay-on-board moving platforms such as high speed trains/buses and other road vehicles, to ensure service reliability for major events in ad-hoc built-up facilities;
- Connectivity for remotely deployed battery activated (M2M/IoT) sensors, or handset devices with messaging/voice capabilities via satellite (e.g. fleet management, asset tracking, livestock management, farms, substations, gas pipelines, digital signage, remote road alerts, emergency calls, mission critical/ public safety communications, etc.);
- Two-way telematics capability enabling automotive diagnostic reporting on connected cars, user base insurance information, safety reporting (e.g. air-bag deployment reporting, advertising based revenue, remote access functions (e.g. remote door unlocking);
- IoT devices on containers (e.g. for tracking and tracing) connected via a Relay UE on a transport vehicle such as a ship, train or truck;
- Broadband connectivity to UASs via satellite consistent with Resolution 155 (WRC-15).

Hybrid Multiplay

This use case is about high speed connectivity including backhaul to individual homes and offices, with the ability to multicast the same content (video, HD/UHD TV, as well as other non-video data) across a large coverage (e.g. for local storage and consumption). The same capability also allows for an efficient broadband connectivity for aggregated IoT data. In-home distribution via Wi-Fi or very small cell ("nano-cell"), is shown in the figure overleaf.

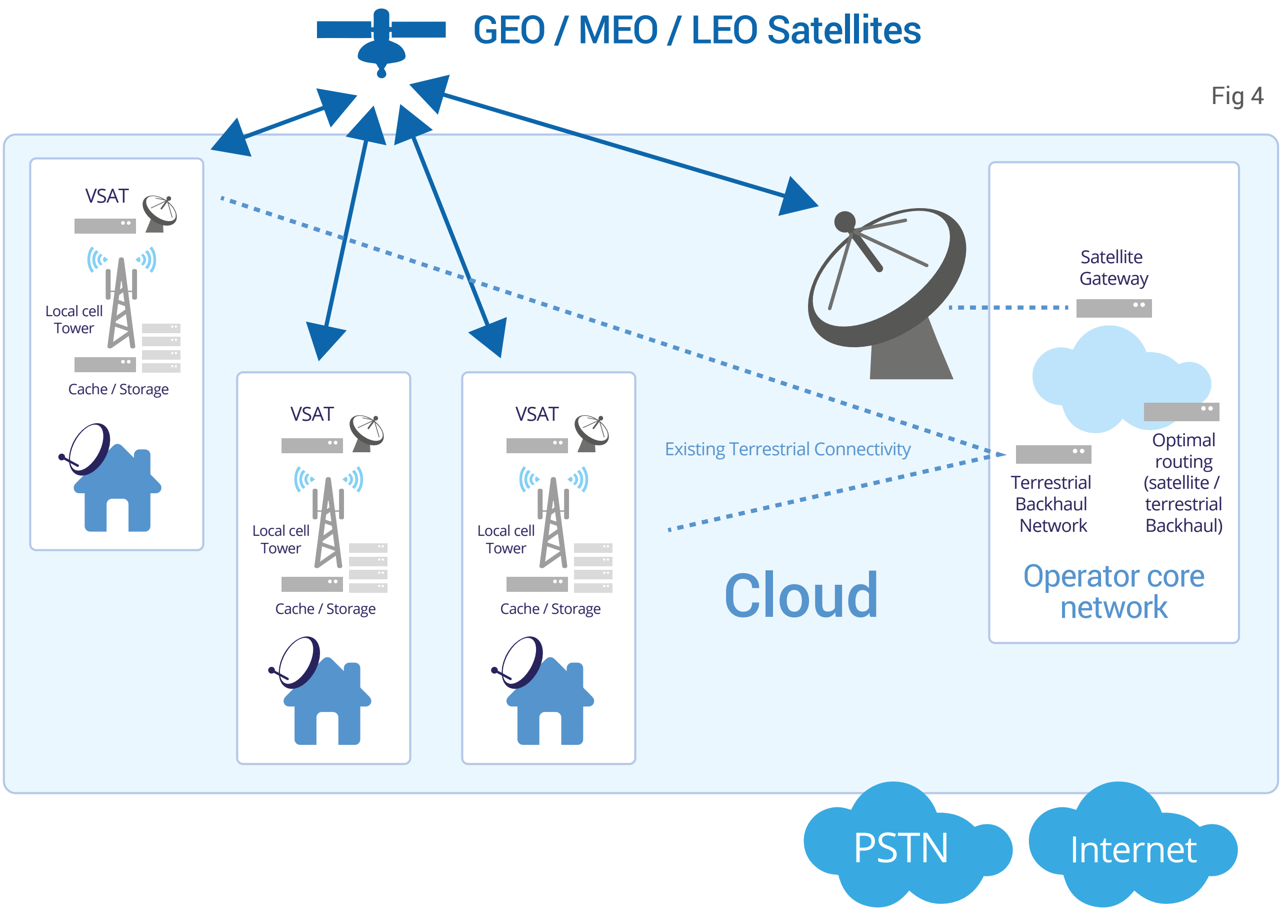


Fig 4

A very high speed, multicast-enabled, satellite link (up to 1 Gbps or even more), direct to the home or office, from geostationary and/or non-geostationary satellites will complement existing terrestrial connectivity. Direct-To-Home (DTH) satellite TV, integrated within the home or office IP network, will further complement this use case.

An example of such a Use Case includes connectivity complementing terrestrial networks, such as broadband connectivity to home/Small Office cell in underserved areas in combination with terrestrial wireless or wire line.

Advanced Satellite Solutions

▶ Today's Satellite Services

High throughput satellite (HTS) networks are operating on a global basis and can provide broadband service to end-users with speeds of 25/3 Mbps and higher.

These systems can support a wide variety of applications, including broadcast and multicast distribution of content, and are instrumental in bridging the digital divide by offering high speed, high capacity, anywhere, anytime services, particularly where terrestrial infrastructure is unavailable. As discussed, below, future systems will have significantly greater speeds and capacity.

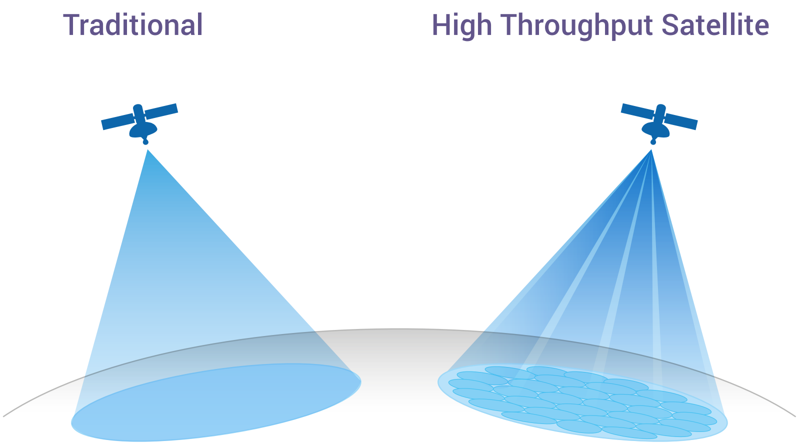


Fig 5 - From traditional wide-beam to HTS satellites

Some of the components of HTS satellites design are:

- Efficiency
- Throughput
- Coverage
- Architecture
- Spectrum

All of these components impact the business model for satellite design and are driven by go-to-market business criteria.

▶ Architecture Considerations

Satellite broadband performance continues to improve:

- **Satellite operators are deploying hybrid networks that support converged broadband and broadcast services;**
- **Ground infrastructure manufacturers continue to enhance the performance of gateways and personal equipment;**
- **Space infrastructure manufacturers maintain a continuous R&D effort to further increase the throughput delivered by the satellite (including by increasing frequency reuse in multiple spot beams, as shown and compared to traditional satellites in Figure 3) while reducing the overall cost of the mission (satellite and launcher) to keep the economic model viable.**

Moreover, the improvement of the economic performance of satellites will continue to be enhanced by the deployment of flexible payloads allowing the services to adapt to evolving service needs, after launch and throughout the satellite lifetime. Being able to optimise the capacity to the market requirements has a direct impact on the overall business model.

Thus, the combination of new satellite network architectures based on Low/Medium Earth Orbit (LEO/MEO) constellations and architectures based on Geostationary Earth Orbit (GEO) satellites means that satellites can play diverse roles to meet multiple service requirements while always leveraging the core strengths of reach and resilience as well as cost and spectrum efficiency.

▶ Advanced Satellite Technology

The dividing lines between satellite and terrestrial networks are softening. Developments in terrestrial wireless networks and services are influencing the prospects for satellite services. In the past, the establishment and configuration of services across satellite and terrestrial segments was mostly performed manually and in a static way. Today, the delivery of services and content over networks, operated by different entities, call for new types of partnership arrangements and for a unified end-to-end control and management. The transition to network function visualization (NFV) and software defined networks (SDN) not only facilitates the integration of network functions of different vendors, it also potentially facilitates the integration of different technologies onto the same platform to:

- **Enable the delivery of high quality end to end performance to the final users;**
- **Differentiate business models (e.g. by introducing inherent flexibility to enable the support of new and innovative services and applications that were not envisaged when the network infrastructure was planned and deployed);**
- **Improve business performance (including the reduction of operation costs and end user terminal pricing).**

This means that satellite technology will "blend in" to the overall 5G network architecture, aligning its NFVs into the edge and core cloud infrastructures. As a consequence:

- **The network management service will manage the traffic directed to the satellite according to bandwidth, latency and other application requirements.**

Satellite technology could have its functions integrated at NFV level, creating a denser and more operable and scalable platform for a telecom operator. In combination with 5G "network slicing", dedicated VNFs could address different connectivity concerns.

Satellite broadband promises fast, flexible internet access from anywhere in the world with major satellite operators already deploying next-generation satellites with high data throughputs. To enable the widespread adoption of satellite broadband, especially for mobile users, the satellite industry is developing next generation terminals using, among other things, a new reconfigurable antenna technology, known as Metamaterials Surface Antenna Technology (MSA-T), shown in Figure 6. This antenna offers the electronic beam-steering performance of a typical phased array antenna, with much lower power consumption offering a dramatic cost reduction compared to mechanical products and many of the size, weight and power challenges associated with the existing techniques are alleviated. No longer will accessing satellites require traditional equipment with high power requirements for the user; new technology is unlocking the full potential to track satellites while also being portable enough to attach to a vehicle or take into the field.

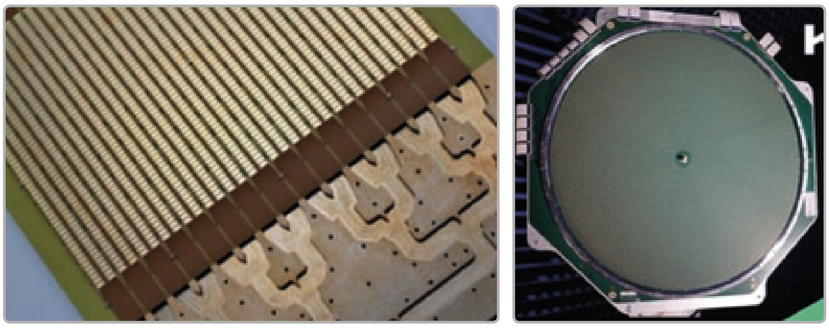


Fig 6 - Antenna array and feed network antenna technology

Ensuring Satellites Can Play a Role

Policy Must Enable the Role of Satellite in 5G

Satellites are a critical component in 5G.

To ensure satellite's ability to meet the growing user demands for broadband, there are certain key principles that regulators and policy makers globally must adhere to:

Technology Neutrality

A stable, resilient, inclusive 5G ecosystem requires the adoption of policies that ensure competition among platforms. Policies that focus solely on the fibre core of 5G networks, or that equate 5G access solely with terrestrial wireless technologies, will fall short of making 5G successful across the globe. Accordingly, it is critical that policymakers take the time and effort to understand how different technologies can and should interwork – trying to integrate an essential component like satellite later, as an add-on, will be inefficient and burdensome and will impose unnecessary additional cost to providers and users alike.

To this end, policy makers must avoid making assumptions or interventions that lead to the creation of blanket 5G requirements for features such as high speed or low latency that will only result in an underperforming or over-engineered 5G network that serves few use cases and the resulting few people. Fostering and incentivising the emergence of common standards from the start to enable an integrated and interworking eco-system of network technologies so that interfaces can seamlessly communicate with different technology solutions (e.g. both GEO,LEO and MEO satellite systems), will further promote the 5G vision.

Cost-Efficiency

Users across the world are disappointed that they do not have the coverage they need where they need it.[7] Accordingly, policy makers should ensure that the most cost-effective platform be supported to meet user demands. Satellite, because of its anywhere, anytime availability will often be the most cost-effective technology, especially in rural and remote regions of the globe.

Access to Spectrum Resources

Spectrum is an issue for all wireless systems, whether terrestrial or in space. As terrestrial mobile systems move into the millimetre wave bands above 6 GHz, where satellite systems have been operating for many years, consideration needs to be given to the co-existence needs of both sectors. A rapid deployment of 5G is best served by focusing the spectrum needs of terrestrial 5G networks to bands other than those used by satellite already. This approach will also ensure that both technologies can work together, each enabling part of the value chain to ensure reliability, reach and quality of service.

Satellites make intensive use of several portions of the frequency spectrum both above and below 6GHz for their services (including for high-throughput satellites in Ku and Ka-band).[8] As a result, and given the long-term nature of these investments, it will be critical to maintain a viable and sustainable access to traditional satellite bands, such as the C, Ku and Ka-band, as well higher bands including the V and Q bands beyond to ensure the growth of the satellite community within these bands.

Standardisation

It is critical that 5G network (global) management / signalling, namely advanced traffic management, develop in a way that leverages the capability of satellite networks to support appropriate applications and services . Progress is being made to include satellite as part of the 3GPP 5G standards[9] and as part of IMT-2020 in the International Telecommunication Union. Such efforts are critical to ensuring that the benefits of 5G networks can be realised.[10]

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7 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/412618/Government_Response_FINAL__1_.pdf . Department of Culture Media and Sport, Tackling Partial Not Spots in Mobile Phone Coverage, 12 March 2015

8 Ku band is 12 – 18 GHz and Ka band 18 – 31 GHz

9 In line with the requirements that "the 5G system shall be able to provide services using satellite access" in 3GPP TS 22.262 "Service requirements for the 5G system; Stage 1 (Release 15)

10 The ITU-T Focus Group on IMT-2020 draft "Report on application of network softwarization to IMT-2020" (IMT-O-041) emphasizes in its recommendations to ITU-T Study Group 13 that "IMT-2020 network architecture is required to include multiple RAN technologies including satellite" and recommends studies "of the integration of satellite technologies into the IMT-2020 network architecture." This should be accomplished in the near term.

Conclusion

Satellites are a critical component of the 5G telecommunications landscape.

They will complement as well as compete with other technologies in meeting the needs of users worldwide. The satellite "sweet spots" of trunking, back-haul, mobility, and hybrid multiplay will be used to complement other high-bandwidth connectivity links, such as broadband fibre optic, xDSL, Wi-Fi, WiGi and even Li-Fi (optical wireless communications)).

Only by this ecosystem of technologies, including satellites in their multiple orbits and frequency ranges, can 5G achieve its vision of bringing next generation connectivity to all users across the globe. Investment and technology decisions are being made now for 5G technologies, and it is important that governments and institutions embrace and foster a "system-of-systems" approach based on common standards and technology neutrality, to minimize the risk of costly and complex changes in the future. By working together, policymakers and industry players will realise a dramatically improved connectivity experience for tomorrow's generation that will deliver ubiquitous services and improve the lives of all citizens.

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